THE ENVIRONMENTAL SIGNIFICANCE OF MANAGEMENT PRACTICES

Exploring the Eco-efficiency of 6 Cases

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Abstract

The starting point for this paper is the importance of understanding how humans interact with material and energy flows. Technical systems are vital to model for improving eco-efficiency, but they are always managed by humans. Daily maintenance of machinery and the process of planning a new warehouse are examples of these ordinary human actions, and such actions are seldom simple cause-effect chains. The purpose of this study is to continue investigating these human actions, through our research on Environmental Assessment of Organising (EAO).

A qualitative screening of environmental impacts through life cycles assessments (LCA) and the human practices influencing these impacts is carried out for six products and services: activities offered at bowling halls, bread production, bus travel services, cement production, properties management and road maintenance. Within each of these studies, at least three product or service chains are compared. LCA is combined with observation studies and interviews.

For each of the six cases, descriptions are presented of situations, where management practices are indicated to be significant for the environmental impacts. The environmental impacts are qualitatively assessed, and further studies are needed for fully describing the cause-effect chains and the size of the differences in environmental significance. For road maintenance, difficulties of determining a useful functional unit, makes comparison of different operators less feasible.

Concluding, many studies of technology, not least innovations, would benefit from including ordinary human actions. Such detailed and realistic socio-material understandings can be used for fruitful theorising and subsequent environmental improvements. As an example, innovation studies might become more efficient by including thorough investigations of the 'ordinary' periods in between innovations.

Keywords

Management practices, Environmental impact, Environmental Assessment of Organising (EAO)

1 Introduction

The starting point for this paper is the importance of understanding how humans interact with material and energy flows. Technical systems are vital to model for improving eco-efficiency, but they are always managed by humans. Daily maintenance of machinery and the process of planning a new warehouse are examples of these ordinary human actions, and such actions are seldom simple cause-effect chains. The focus in the field Industrial Ecology is on the study of technical systems, but human actions are often described and mentioned as important in IE studies and highlighted in the aims of the journals in the field (Lindkvist, et al., 2010). These contributions are, however, scattered and an aiming for constructing a theoretical framework is yet to be seen (Lindkvist, et al., 2010). A similar untapped potential for integrating social and technical research is present in Management and Organisation studies (Baumann, 2004).

Therefore, we here present an investigation into furthering the understanding of the management practices while pointing out hot spots by using environmental quantitative assessments. In practice, this is performed by screening six different products and services for environmentally significant differences in management practices. A qualitative discussion of the quantitative environmental significance is presented, one objective being to point out at least one of these six cases as feasible for a further deep study.

2 Theory and method

This study is a continuation of research on Environmental Assessment of Organising (EAO) (see e.g. Baumann, 2008). This far EAO research has covered one investigation area in depth, properties management (see Brunklaus, 2008), which is presented as one of the six cases in this study. Below follows the theoretical and methodological base used by and developed within EAO.

Material and energy flows is one of three theoretical foundations for EAO. From a systems perspective (Simon, 1962), material and energy flows are often strongly dependent on each other (see e.g. Baumann & Tillman, 2004). This is valid both for a product, and for the materials and energy needed to provide a service. This perspective is used in this study through the tool Life cycle assessment (LCA), following supply chains both upstream and downstream.

The concept of organising is used in addition to the physical life cycle flows. Organising refers to the ordinary human actions mentioned in the introduction, and acknowledges that these actions are processes that occur during a time span—as opposed to instantly (Czarniawska, 2005, Weick, 1979).

The third theoretical concept used here, socio-material interaction (SMI), aims at connecting physical flows and organising. It was developed during EAO research for understanding the findings (Baumann, 2008, Lundberg 2008). It follows the physical flows to find the environmentally relevant interaction between humans and for example machinery, or rivers (not only technical entities).

The methodological approach used here follow Grounded theory (GT). GT is a strategy for formulating theoretical explanations. Previously collected field data is repeatedly re-analysed as new data is collected, thereby maximising the theoretical gain per effort spent on retrieving and analysing data. In order to make the data collection efficient, the most suitable collection technique for each situation is proposed, whether it is observation, interviews, measurements, documents or literature. (Glaser & Strauss, 2006 [1967])

3 Selection of the studied cases

Six cases have been chosen, each of which had at least three product or service chains with the same or similar functional unit, using the methodology of LCA. In Table 1 the six cases are listed, and information is also provided about whether the study concerns mainly a product or service. Also, when applicable, previous research about environmental significant practices is stated.

Table 1: Overview of the six studied cases

Case		Product or service	Previously studied environmentally significant practices
1	Bowling hall services	Service	
2	Bread production	Product	- Scale of business (Andersson)
3	Bus travel services	Service	
4	Cement production	Product	- Production pattern (von Bahr) - Measurements (von Bahr)
5	Properties management	Service	- Energy control pattern (Brunklaus, 2008); - Renovations planning (Brunklaus, 2008)
6	Road maintenance	Service	

In this study socio-material interaction (SMI) is used both as an aid for finding the environmentally relevant management practices and for structuring the presentation of the findings. To delimit the study, SMI is only investigated within one part of the product and service life cycles, and this is supported by the fact that environmentally significant actions always connect to at least one part and that findings from previous research show that the parts chosen connect to environmentally significant actions.

In the six following chapters, the cases are presented.

4 Bowling hall services (Case 1)

Three of the bowling halls in Göteborg have been studied. They all offer public bowling and supply balls and shoes for customers. Recently, the form of bowling called ‘disco bowling’ has emerged and is now provided in the entire halls during a major part of the opening hours at the bowling halls in Göteborg. Since this form of bowling sometimes requires that the players are adults—because of a combination of selling alcohol during these hours and targeting an adult customer group—the functional unit has been chosen to be defined for adult customers. Also, a reasonable unit of comparison should be based on the service of performing a desired amount of bowling, which could depend on the offering of other services simultaneously. Therefore, one bowling occasion per customer is chosen, rather

than actual bowling time or time spent at the bowling lane. Taken together, this gives the functional unit 1 adult's public bowling occasion.

4.1 About the three bowling services

Valhalla Bowling, ***Star Bowling*** and ***Inter Bowling*** are all medium sized bowling halls, located rather close to the city centre. Some general information about the three halls is found in table 2.

Table 2: Overview of the three bowling services

	Valhalla Bowling	Star Bowling	Inter Bowling
Prices and opening hours	Moderate pricing (lower than Star Bowling and Inter Bowling)	260-340 SEK/person/55 min (discounts for youths, seniors, and particularly families)	260-320 SEK/person/55 min (discounts for youths and particularly families)
	Open from around noon till late evening	Open from around noon till around midnight (closes earlier on Sundays)	Open from around noon till around midnight
General management	No web page.	Moderately simple web page	Moderately simple web page
	Has a small kiosk, but otherwise no additional offers	Offers food and alcohol in their restaurant next to the lanes	Offers food and alcohol in their restaurant next to the lanes
	-	Offers other indoor leisure activities	-
	Customers under 18 to a large extent	Targets kick-offs and similar events	Targets children parties as events

4.2 Environmental screening of the three bowling services

The socio-material interactions with environmental consequences take place at, A: decisions on which bowling services to provide, and B: hall maintenance. The environmental consequences related to socio-material interaction points are developed in the following.

4.2.1 Bowling services provided (A)

Disco bowling is characterised by high volume music and dim lighting (fluorescent). The amount of active bowling time per person and bowling occasion may vary between regular bowling and disco bowling, due to the variation in other simultaneous activities such as

music and bar service. See Table 3 for a description of the bowling services provided, and their environmental significance.

Table 3: Bowling services provided (A)

Valhalla Bowling	Star Bowling	Inter Bowling
Regular bowling only	Disco bowling only	Disco bowling in the evenings (for some hours offered for all ages). Regular bowling at day time.
➔ More detailed studies of the services and the use of them may reveal environmental differences between the three studied bowling halls		

4.2.2 Hall maintenance (B)

A bowling lane is covered by a surface that needs to be both smooth and protect the material below it. Well planned maintenance is needed in order for the balls not to destroy the surface and cause large damages that need repair. The air humidity and temperature also need to be held within certain ranges for the surface layer not to be damaged, making control of these parameters important and a wise planning of the facilities interior and its access to areas with other level of moisture and temperature vital. The amount and type of equipment such as scorecard monitors impact the environment via their life cycles. See Table 4 for a description of the hall maintenance and equipment, and their environmental significance.

Table 4: Hall maintenance and equipment (B)

Valhalla Bowling	Star Bowling	Inter Bowling
No direct access to the outdoors environment	Located far below the entrance from the street	Entrance directly from the street
The lanes and equipment is partly old and also in need of maintenance	New and technically advanced scorecard monitors	Relatively new and relatively technically advanced scorecard monitors. The monitors are designed for showing advertisement.
➔ More detailed studies of the hall maintenance and equipment may reveal environmental differences between the three studied bowling halls.		

5 Bread production (Case 2)

Many bakeries are producing bread in the Göteborg metropolitan area. Three of these have been selected for this study, representing different scales of business since previous research point out that this could be a factor determining the environmental impact of their life cycles (Andersson & Ohlsson, 1999). The unit of comparison in previous LCAs on bread production has been 1 kg bread (see e.g. Roy, et al., 2009). However, no motivations are provided for this choice of unit. Since LCAs on other food products often use 1 KJ as a unit of comparison (Roy, et al., 2009), and since the number of bread slices that are eaten can be assumed to correspond to the concentration of energy in the bread, 1 KJ eaten by humans is used in this study. Some factors may make bread a less suitable EAO study object—different taste of different bread types, different access to different types of retailers, and that the time until the bread is not edible or tasty any more varies depending on bread type—but these characteristics are part of the different ways of organising bread production and bread is one of the food staples, and will therefore probably so remain.

5.1 About the three bread chains

Pågen is a large scale industrial bread producer, shipping all over Sweden and to the closest neighbouring countries as well. Its share of the Swedish market is approximately 30% and around half of its production comes from a bakery in Göteborg (here studied) and half of it from a bakery in Malmö. All bread produced is wrapped and sold via major supermarket chains. At the Göteborg bakery, and the number of employees amounts to around 700.

Dahls is a local company that is focused on supplying newly baked and non-wrapped bread to supermarkets in the Göteborg metropolitan area. Their production is semi-industrialised and divided between two bakeries, one of them having been acquired a few years ago. Here, the bakery that they have owned for a run for a longer time period, is studied. This bakery employs around 40 persons.

Le pain francais is a local chain of six bakeries and adjacent coffee shops. In total, they employ around 30 persons.

5.2 Environmental screening of the three bread chains

The socio-material interactions with environmental consequences take place at, A: purchasing of supplies, B: baking and factory planning, C: packaging and distribution to

retailer and customer. The environmental consequences related to socio-material interaction points are developed in the following.

5.2.1 Purchasing of supplies (A)

The main ingredient for bread production is flour, often dominated by different types of wheat flour. However, the bakeries often produce buns, cakes and similar products, and these require many, and often exotic, ingredients. The amount of flour needed, combined with the relative amount of flour of the total ingredients, impact the organisation of the purchasing, which may influence the need of supplies transportation. See Table 5 for a description of the purchasing of supplies, and its environmental significance.

Table 5: Purchasing of supplies (A)

Pågen	Dahls	Le pain francais
Nearby mill	Separate flour delivery	-
Selected farms	Purchasing via an organisation owned by many bakeries	-
Few exotic ingredients	Moderate number of exotic ingredients	Many exotic ingredients. Supplies for coffee shops.
➔ More detailed studies of the purchasing of supplies may reveal environmental differences between the three studied bread chains.		

5.2.2 Baking and factory planning (B)

Measuring can be performed by direct estimation, via displays near the production and in remote control rooms. A higher degree of automation of measuring may increase the possibility to act but the person receiving the information must be able to interpret it well. The degree of automation also influences the distances bakers have to cover in the bakery and the degree to which the baking machinery is built together. Covering large areas may decrease the possibility for exchanging information about the state of the production between staff. A built together machinery makes it more difficult to continue the rest of the process if one step fails. Protection against contamination in the bakery is used for producing a bread that needs longer storage time until it becomes unedible, thereby possible lowering the need for customers to use freezers or fridges or lowering their need of transportation if bread is bought less often. Thin bread requires less baking time in the oven

than loaves (around 3 and 8 minutes, respectively). See Table 6 for a description of the baking and factory planning, and their environmental significance.

Table 6: Baking and factory planning (B)

Pågen	Dahls	Le pain francais
Extensive use of measuring devices. Local and remote.	Moderate use of measuring devices.	-
Built together machinery. Direct and remote steering. The bakers cover large areas.	Partly built together machinery. Only direct steering. The bakers cover small areas. Team work. Work rotation. Non-hierarchical working environment.	-
The bread is protected from bacteria etc. Automatic monitoring of contamination such as small stones.	No protection of the bread from bacteria etc. No monitoring of contamination such as small stones.	-
Experts at producing thin bread	-	-
➔ More detailed studies of the baking and the factory planning may reveal environmental differences between the studied bread chains.		

5.2.3 Packaging and distribution to retailer and customer (C)

The scale of business is closely connected to the distances of distribution to retailer or customer. Related to this scale is the material used for wrapping, being plastics for long distance distribution. Also partly related to the scale of the bakery's business is the type of retailer, and especially its scale of business, which determines the distance needed for the customer to transport the bread. See Table 7 for a description of the packaging and distribution to retailer and customer, and their environmental significance.

Table 7: Packaging and distribution to retailer and customer (C)

Pågen	Dahls	Le pain francais
Long distances to retailers (all of Sweden and more)	Retailers mainly in the Göteborg metropolitan area	Sold directly to customers
The retailers belong to major supermarket chains	The retailers belong to major supermarket chains	Sold directly to customers
All bread is wrapped at the factory	Mostly not wrapped before sale	-
Planned overproduction (3 %, planned take back, which is used for producing pig feed).	-	-
➔ The transportation needs seem to vary significantly between the bakeries. More detailed studies of the packaging and distribution to retailer and customer can be used for revealing the cause-effect chains and thereby determining the environmental differences between the studied bread chains.		

6 Bus travel operation (Case 3)

The distance Göteborg–Oslo is trafficated by three bus companies. It is of course also possible to take the train, to fly or drive yourself, but for many, the bus is their first choice owing to low prices and the great number of departures per day.

The G-O distance is presently (Sept 2010) operated by three different bus companies: Swebus Express, GoByBus and Bus4You. There are many similar, to not say identical, traits between the services the three companies provide: their route to Oslo is of course the same, but also their timetables have identical departure times and their stops are next to each others at the Göteborg bus station. Since the services provided are almost identical, they make suitable candidates for an environmental screening of their respective socio-material organisation. The Göteborg-Oslo services, together with necessary surrounding arrangements can be illustrated as in Figure 1. Empirical material consists of observation at bus terminals and through travelling, brochures at sales points and internet documents. The field work has been carried out intermittently between February 2009 and September 2010.

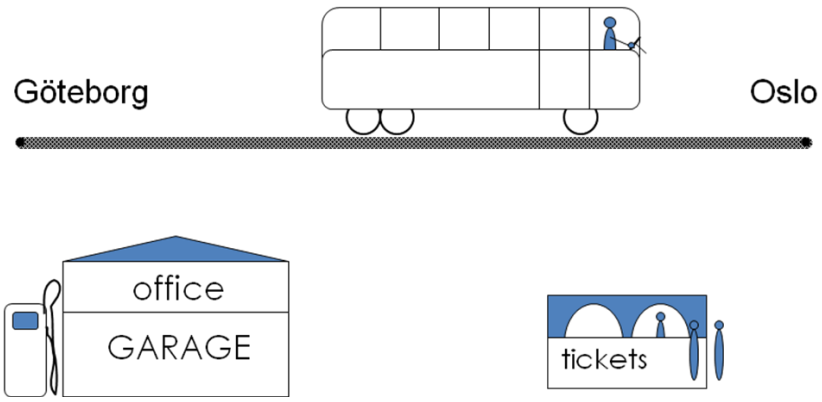

Figure 1: The Göteborg-Oslo bus services, together with necessary surrounding arrangements

6.1 About the three bus services

Swebus Express is a fairly large operator of scheduled public road transport services. They claim to be the leading express bus company in Sweden with 10,000 departures per week and over 2 million passengers per year. Their bus services are since 2009 eco-labelled with 'Bra Miljöval' (Good Environmental Choice), issued by the Swedish Society for Nature Conservation. They publish an environmental report and also their environmental work on the internet. The company is presently owned by Nobina, previously known as Concordia. All in all Swebus presently operates 30 long-distance lines, reaching more than 150 destinations. Their destinations are mainly in Sweden, but close cities such as Oslo and Copenhagen are also included in their network. The Göteborg-Oslo line is their line no. 820. It also extends southwards, connecting to Copenhagen and further down the continent.

GoByBus is a bus a smaller bus operator. Its recent organisational history is a little tangled. Until 2006, it was known as Säfflebussen and run by an entrepreneur from Säffle. In 2006, Säfflebussen was acquired by Nettbuss, a Norwegian bus company mainly operating local and regional lines in Norway. In 2008, Säfflebussen merged with the small, new bus operator ***Bus4You*** and Säfflebussen changed its name into GoByBus. GoByBus and Bus4You are more or less run as two separate companies, but they share garage and head offices in Borås, 50 km west of Göteborg. While GoByBus claim to provide the cheapest trips, Bus4You sell "luxurious and comfortable" trips with their 3 leather seats (2 + 1 seats) per row, wireless internet onboard and electricity sockets by each place. GoByBus and Bus4You each operate only 2 lines, their Oslo-line being one of them.

6.2 Environmental screening of the Göteborg–Oslo bus services

To carry out an environmental comparison of the competing bus services, one must identify a unit of comparison, which corresponds to the functional unit in LCA methodology. Here, the unit of comparison is approximately 'environmental impact/person-km'.

In order to understand the environmental impact generated by three companies, respectively, it is necessary to look into the organisation enabling the physical transport. Figure 1 can be complemented by the identification of where socio-material interactions take place, see Figure 2. Interaction points with environmental consequences are, A: driving style, B: ticket sales, C: servicing, maintenance and repairs at the garage, and D: fleet management, marketing, and routing and scheduling at the offices. A summarised overview of the organisation around A, B, C and D for the three bus services is found in Tables 8-12. The environmental consequences related to socio-material interaction points are developed in the following.

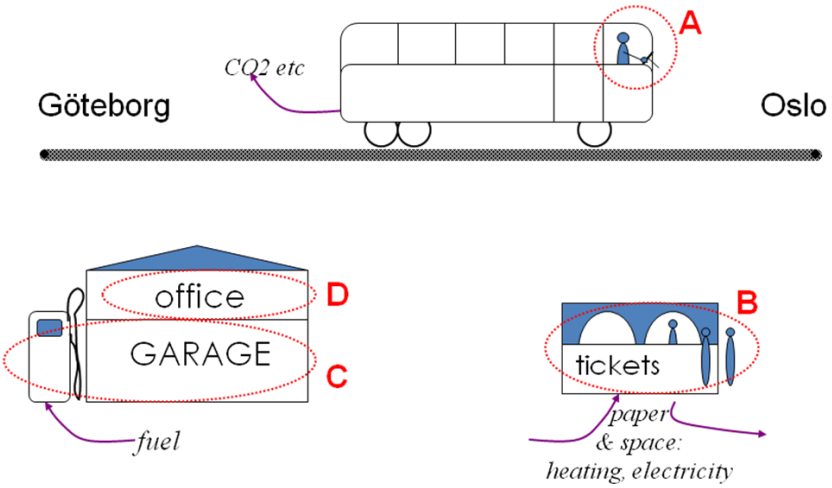

Figure 2: The socio-material interactions of the Göteborg–Oslo bus services

Table 8: Overview of general characteristics of three bus services from Göteborg to Oslo (as of Sept 2010)

	Swebus Express, 820 to Oslo	GoByBus to Oslo	Bus4You to Oslo
Travel service	Up to 10 departures/day	5 departures/day	2 departures / day
	Many trips are non-stop, with a travel time of 3:35; others include stops en route, extending travel time to a maximum of 3:50	Travel times between 3:48 and 3:50	Travel time 3:35
	177 SEK, price for one-way trip on a weekday	216 SEK, price for a one way trip on a weekday (adults; students and particularly senior citizens considerable pay less)	243-290 SEK, price for a one-way trip on a weekday (adults; students and senior citizens pay less)
General management:	Markets itself as the company with flexible travelling to many destination (has free wireless internet and electricity sockets by each seat, but it is not a prominent marketing point)	Markets itself as the friendly and supercheap company: 'only bicycling is cheaper'; (has free wireless internet on some of their buses, but this is not a marketing point)	Markets itself as 'affordable luxury' and 'faster than the train, more comfortable than flying' with only 2 + 1 seats/row, free wireless internet and electrical sockets by each seat.
	Has large website with pages describing fleet management, environmental strategy, research on public transportation, etc	Limited amount of company information on company; website mainly dedicated sales of bus travels	Limited amount of company information on company; website mainly dedicated sales of bus travels

6.2.1 Driving style (A)

Buses have different gearboxes than cars. There are, for example, gear boxes with 12 gears, as well as automatic ones. Also, there is more than one way to brake. This means that drivers develop personal driving styles, with great differences in fuel efficiency. Different driving styles could theoretically lead to ± 15% differences in CO_2 emissions. A detailed study of driving styles could be interesting to follow up in further study of the bus services.

Table 9: Driving style and its organisation (A)

Swebus Express, 820 to Oslo	GoByBus to Oslo	Bus4You to Oslo
Most drivers have calm and smooth driving styles. Only occasionally one ends up with a brusque driver. Buses are usually on time.	Most drivers have calm and smooth driving styles	Most drivers have calm and smooth driving styles
Drivers get training in 'eco-driving'; eco-driving skills often discussed by drivers	No info on eco-driving	No info on eco-driving
➔ A more detailed study of driving styles in practice and driver's training could reveal environmental differences between the three studied bus services		

6.2.2 Ticket sales (B)

Tickets are to a great extent sold via the bus companies' web sites, but tickets are also sold over the phone, via the applications on mobile phones and over the counter at the bus terminal. Ticketing used to be paper-based, but have in a short period of time become—ranging from emailed tickets with a bar code to a code as an SMS to be shown to the driver when boarding. The environmental impact related to ticket sales depend thus on the digital solution and to the space for ticket sales in bus terminals.

Table 10: Ticket sales and its organisation (B)

Swebus Express, 820 to Oslo	GoByBus to Oslo	Bus4You to Oslo
Small sales office with 2-3 counters in the bus terminal	Bigger sales office with 1 counter in the bus terminal	Share sales office with GoByBus
Stall with timetables, offers, etc	Big posters, lots of brochures, lots of lights	Sales procedures similar as GoByBus
Serves customers for all their other lines as well; often people queuing	Serves customer for 2 lines; one armchair for waiting customers, no queuing system	Sales procedures similar as GoByBus
Paper tickets over the counter; booking code over the internet	Paper tickets over the counter or via email (no booking code)	Sales procedures similar as GoByBus
-	Customer can register on the internet to view their bookings, travelling history, receive offers, etc	-
-	-	For an extra fee, customer can book their seat
➔ It is difficult to say anything about the environmental consequences of the e-ticketing; the Swebus sales office in Göteborg is more space efficient/customer than those of GoByBus and Bus4You		

6.2.3 Servicing, maintenance and repairs (C)

Buses are fuelled and cleaned at the bus garage. That is also where service checks, maintenance and repairs are carried. The location of the garage decides whether fuelling and cleaning the bus entails extra kilometres.

Table 11: Servicing, maintenance and repairs and its organisation (C)

Swebus Express, 820 to Oslo	GoByBus to Oslo	Bus4You to Oslo
Servicing is done in at garages in close proximity to bus terminal	Servicing is done at garage near Borås	Servicing is done at garage near Borås
➔ Swebus has the environmental advantage of bus garages close to the bus terminal, while the garage servicing GoByBus and Bus4You buses is some 50 km away		

6.2.4 Bus fleet management (D)

Owing to relatively small production series, the interior of buses can be more or less hand-built and tailored to the needs of the clients. This allows each bus operator great freedom when ordering new buses. This also leads to different number of seats per bus, which in turn affect passenger eco-efficiency. Furthermore, age of bus, engine type and frequency of servicing influence fuel efficiency. In short, bus fleet management is crucial to the eco-efficiency of the bus journey.

Table 12: Bus fleet management and its organisation (D)

Swebus Express, 820 to Oslo	GoByBus to Oslo	Bus4You to Oslo
Ordinary 2+2 seats/row; velvety upholstered seat	Ordinary 2+2 seats/row; velvety upholstered seat	Special feature: leather seats, only 3 (2+1) seats/row
Varying age of buses, but older buses are replaced on a regular basis	New buses	Only brand new buses
Ca 50% are on lease; 50% are owned	No information on ownership of fleet	No information on ownership of fleet
No information on frequency of servicing	No information on frequency of servicing	No information on frequency of servicing
Scheduling is said to consider rush hours to avoid unpredictable travel time and to reduce emissions	No information on scheduling, but has adopted more or less identical timetable as Swebus	No information about scheduling
➔ GoByBus and Bus4You have the environmental advantages of new buses, whereas the Swebus Express bus fleet is of a more varied age. A more detailed study could look into the distribution of engine types (Euro 1-5) and use of alternative fuels. Bus4You has an environmental disadvantage relative the other two companies owing to lower passenger efficiency.		

The environmental screening does not single out any of the bus services as greener than the other—a more detailed study is necessary for that. It points to certain green advantages of scale when it comes to servicing and drivers' training for Swebus Express but it also points to certain green advantages owing to the new of buses of GoByBus. Nevertheless, the screening shows that the environmental performance is not easily deduced from distance and bus type as is the case in ordinary LCA. Here it is shown that, for example, emissions of carbon dioxide depend on a multitude of factors: driving style and driver's training (A), type of bus, engine and scheduling (D), and location of garage for servicing, cleaning and repairs

(C). Even if no quantitative environmental differences were produced, the screening study showed has at least shown that the bus companies operate with different business models (affecting passenger-km) and with different approaches to innovation and fleet management (affecting emissions), and the eco-efficiency depends on an intricate interplay of management with technology.

A more detailed study could hopefully produce numbers on CO_2 emissions / passenger-km, by combining the study of the organisation for CO_2 emissions with the study of the organisation of marketing and sales. It is worth mentioning that bus companies often become door openers for alternative fuels and power-trains. In Sweden, alternative fuels such as ethanol, biogas, etc, were first introduced via bus companies. This could also be discussed in a more detailed study.

7 Cement production (Case 4)

The functional unit used for studying cement production is 1 kg cement (see e.g. von Bahr, et al., 2003).

In Sweden, three cement production plants are located, all nearby rich sources of limestone, which is the major component when producing cement. The three plants belong to the company Cementa AB, which is fully owned by the Germany based enterprise HeidelbergCement.

Environmentally significant socio-material interaction has been found in the relations between the plants and the legal authorities and in the factory operation.

Being major industries, the cement plants have rigorous obligations to report on for example environmental performance, and are also inspected regularly. In one of the legal frameworks, the maximum allowed production volume is regulated. Production above this level, requires a new legal contract to be established. During one such negotiation, several of the emissions levels at one of the Swedish cement plants was decreased from very high levels to lower levels than the authorities first demanded. A closer study of this negotiation process may reveal environmentally significant practices.

Of environmental importance in the factory operation may be its stability (von Bahr, et al., 2003), the use of measurements (von Bahr, et al., 2003), well planned stops of the burning process (since the cement production process needs much extra heating on startup to get to

working temperature and since the emission during this phase may be significantly higher), and a well working prioritising of which problems at the plant to target (because of a highly rationalised work force).

8 Properties management (Case 5)

The functional unit for properties management is 1 m^2 apartment area.

A deep study of properties management has been performed, using and formulating the EAO framework. Both regulation of supply of heating and water, and renovation were shown to be carried out using different approaches in two compared residential housing estates. A local caretaker adapted to the needs of the house in one of the estates, resulting in low and stable use levels of heating and water and in relevant measures taken to environmental improvements when renovating. The other strategy—regular, emergency driven, or law driven—resulted in high and unstable performance and without a clear path of improvements of the performance over the years. (Brunklaus, 2008)

9 Road maintenance (Case 6)

The functional unit that road maintenance should be attributed to depends on the type of roads. The basis for this case is the three highways between Göteborg and three towns in the outer parts of the Göteborg metropolitan area—Kungälv, Alingsås, and Kungsbacka. These are roads with intense and heavy traffic, and the tear of the road surface—the repair of which is one of many maintenance tasks (Faith-Ell, 2000)—could be expected to be caused mainly by the traffic. Other maintenance tasks depend on combination of factors such as road length, and vehicles intensity and climate (for example, ice control, snow clearing and clearing of the road sides). Since all these tasks are performed by the same operator, it will be difficult to attribute for example the transportation needed from the garage to the location where maintenance is performed.

10 Conclusion

For each of the six cases, descriptions are presented of situations, where management practices are indicated to be significant for the environmental impacts. The environmental impacts are qualitatively assessed, and further studies are needed for fully describing the cause-effect chains and the size of the differences in environmental significance. For road maintenance, difficulties of determining a useful functional unit, makes comparison of different operators less feasible.

Many studies of technology, not least innovations, would benefit from including ordinary human actions. Such detailed and realistic socio-material understandings can be used for fruitful theorising and subsequent environmental improvements. As an example, innovation studies might become more efficient by including thorough investigations of the 'ordinary' periods in between innovations.

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